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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Our Docket No.: AMT-9704C

January 21, 2000

CONTINUED PROSECUTION APPLICATION TRANSMITTAL UNDER 37 CFR 1.53 (b)

Honorable Commissioner of
Patents and Trademarks
Box CPA
Washington, D.C. 20231

Dear Sir:

This is a request for filing a Continued Prosecution Application under 37 CFR 1.53(b) of application serial Number 08/932,078 filed May 27, 1997, entitled"Speaker Verification Method"

Enclosed are:

x 25 pages specification, 1 page of Abstract, and 7 sheet(s) of Drawings.

x The prior application is assigned of record to Ameritech Corporation.

x Copy of Declaration combined with Power of Attorney

x A preliminary amendment is enclosed to be entered in the new application after a filing date has been granted.

____ An Information Disclosure Statement with Copies of references..

x The filing fee is calculated below:

CLAIMS AS FILED, LESS ANY CLAIMS CANCELLED BY AMENDMENT

	NUMBER FILED	NUMBER EXTRA	RATE	ADDITIONAL FEE
TOTAL CLAIMS	10- 20 =		X $18	= $ 0.00
INDEPENDENT CLAIMS	0- 3 =		X $78	= $ 0.00
MULTIPLE DEPENDENT CLAIMS			$260	= $ 0.00
			BASIC FEE	=$690.00
			TOTAL FILING FEE	=$ 690.00

____ Priority under 35 U.S.C 119 is claimed on the basis of prior application Serial No. _____, filed on _____. A certified copy of this foreign application was previously filed in the parent application.

x Amend the specification by inserting before the first line the sentence:
--This is a x continuation ____ division of copending US application Serial No. 08/863,444, filed on May 27, 1997, which application is hereby incorporated by reference herein."

Please Forward all Correspondence to

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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANTS: Bossemeyer, Jr. et al. EXAMINER:

SERIAL NO.: GROUP:

FILED: CASE NO.: AMT-9704C(A00349C)

ENTITLED: Speaker Verification Method

Law Offices of Dale B. Halling
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January 21, 2000

Preliminary Amendment

Honorable Commissioner of
Patents and Trademarks
Washington, D.C. 20231

Sir:

Please enter this amendment prior to examination.

In the specification:

Please change ""one)" to --"one")-- at page 9, line 10.

In The Claims:

Please cancel claims 1-21 and add new claims 22-31

22(new). A speaker verification method comprising the steps of:

(a) generating a code book covering a plurality of speakers having a plurality of training utterances for each of the plurality of speakers, wherein a first utterance of the plurality of training utterances is not the same as a second utterance of the plurality of training utterances;

(b) receiving a plurality of test utterances from one of the plurality of speakers, wherein a first of the plurality of test utterances is not the same as a second of the plurality of test utterances;

(c) comparing each of the plurality of test utterances to each of the plurality of training utterances for the speaker to form a plurality of preliminary decisions, one preliminary decision of the plurality of preliminary decisions for each of the plurality of test utterances; and

(d) combining the plurality of preliminary decisions to form a verification decision.

23(new). The method of claim 22, wherein step (d) further includes the steps of:

(d1) weighting each of the plurality of preliminary decisions.

24(new). The method of claim 23, wherein the step of weighting includes determining a historical probability of false alarm for each of the plurality of utterances.

25(new). The method of claim 23, wherein the step of weighting includes evaluating a quality of the preliminary decision for each of the plurality of decisions.

26(new). The method of claim 22, wherein step (a) further includes the steps of:

(a1) separating the plurality of speakers into a male group and a female group;

(a2) determining a male variance vector from the male group;

(a3) determining a female variance vector from the female group.

27(new) The method of claim 26, wherein step (b) further includes the step of:

(b1) determining if the speaker is a male.

28(new). The method of claim 27, wherein step (c) further includes the steps of:

(c1) when the speaker is male using the male variance vector to determine a weighted Euclidean distance between each of the plurality of test utterances and the plurality of training utterances.

29(new) A method of speaker verification, comprising the steps:

(a) receiving a plurality of test utterances from a speaker;

(b) determining if the speaker is a male;

(c) when the speaker is male, using a male variance vector to determine a weighted Euclidean distance between each of the plurality of test utterances and the plurality of training utterances;

(d) forming a preliminary decision for each of the plurality of test utterances to form a plurality of preliminary decisions;

(e) combining the plurality of preliminary decisions to from a verification decision.

30(new). The method of claim 29, further including the steps of:

(f) when the speaker is not male, using a female variance vector to determine a weighted Euclidean distance between each of the plurality of test utterances and the plurality of training utterances;

(d) forming a preliminary decision for each of the plurality of test utterances to form a plurality of preliminary decisions;

(e) combining the plurality of preliminary decisions to from a verification decision.

31(new). A speaker verification method comprising the steps of:

(a) receiving a plurality of different test utterances from a speaker;

(b) comparing the plurality of different test utterances to a plurality of training utterance for the speaker to form a plurality of preliminary decisions;

(c) combining the plurality of preliminary decisions to form a verification decision.

Remarks

The applicants have canceled claims 1-21 and have added new claims 22-31, which are fully supported by the specification.

Respectfully submitted,

(Bossemeyer, Jr. et al.)

By _____
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I hereby certify that an Amendment is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231, on:

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Signature (Dale B. Halling)

SPEAKER VERIFICATION METHOD

Field of the Invention

The present invention is related to the field of speech recognition systems and more particularly to a speaker verification method.

Background of the Invention

Speech recognition and speaker verification use similar analysis tools to achieve its goals. An input utterance is first processed to determine its essential characteristics. Typically, input utterances are converted to cepstrum coefficients. A cepstrum is an inverse Fourier transform of the log power spectrum. In a training phase the cepstrum coefficients are saved to form code books for specific utterances. For instance, a code book might have codes for the numeral zero through nine. In speech recognition, an input utterance is compared to the codes (training utterances) in the code book to determine which is most similar. In speech recognition the code is a generalized representation of many people's way of forming an utterance (e.g., "zero"). In speaker verification the codes represent the individual characteristics of the

speaker and the verification system tries determine if a person's code is more similar to an input utterance, than an impostor code. As a result the codes in a speaker verification system emphasis individual characteristics, while in a speech recognition system the codes generalize over many individual speakers. Speaker verification has potential applications in a number of voice activated systems, such as banking over the telephone. Unfortunately, present speaker verification systems have not proven reliable enough for these applications.

Thus there exists a need for an improved speaker verification system.

Summary of the Invention

An improved speaker verification method consist of the following steps: (1) generating a code book covering a number of speakers having a number of training utterances for each of the speakers; (2) receiving a number of test utterances from a speaker; (3) comparing each of the test utterances to each of the training utterances for the speaker to form a number of decisions, one decision for each of the number of test utterances, (4) weighting each of the decisions to form a number of weighted decisions; and (5) combining the plurality of weighted decisions to form a verification decision.

Brief Description of the Drawings

FIG. 1 is a block diagram of an embodiment of a speaker verification system;

FIG. 2 is a flow chart of an embodiment of the steps used to form a speaker verification decision;

FIG. 3 is a flow chart of an embodiment of the steps used to form a code book for a speaker verification decision;

FIG. 4 is a flow chart of an embodiment of the steps used to form a speaker verification decision;

FIG. 5 is a schematic diagram of a dial-up service that incorporates a speaker verification method;

FIG. 6 is a flow chart of an embodiment of the steps used in a dial-up service; and

FIG. 7 is a flow chart of an embodiment of the steps used in a dial-up service.

Detailed Description of the Drawings

Several improvements in speaker verification methods are described and then a dial-up service that can incorporate these improvements is explained. FIG. 1 is a block diagram of an embodiment of a speaker verification system 10. It is important to note that the speaker verification system can be physically implemented in a number of ways. For instance, the system can be implemented as software in a general purpose computer connected to a microphone; or the system can be implemented as firmware in a general purpose microprocessor connected to memory and a microphone; or the system can be implemented using a Digital Signal Processor (DSP), a controller, a memory, and a microphone controlled by the appropriate software. Note that since the process can be performed using software in a computer, then a computer readable storage medium containing computer readable instructions can be used to implement the speaker verification method. These various system architectures are apparent to those skilled in the art and the particular system architecture selected will depend on the application.

A microphone 12 receives an input speech and converts the sound waves to an electrical signal. A feature extractor 14 analyzes the electrical signal and extracts key features of the speech. For instance, the feature extractor first digitizes the electrical signal. A cepstrum of the digitized signal is then performed to determine the cepstrum coefficients. In another embodiment, a linear predictive analysis is used

to find the linear predictive coding (LPC) coefficients. Other feature extraction techniques are also possible.

A switch 16 is shown attached to the feature extractor 14. This switch 16 represents that a different path is used in the training phase than in the verification phase. In the training phase the cepstrum coefficients are analyzed by a code book generator 18. The output of the code book generator 18 is stored in the code book 20. In one embodiment, the code book generator 18 compares samples of the same utterance from the same speaker to form a generalized representation of the utterance for that person. This generalized representation is a training utterance in the code book. The training utterance represents the generalized cepstrum coefficients of a user speaking the number "one" as an example. A training utterance could also be a part of speech, a phoneme, or a number like "twenty one" or any other segment of speech. In addition to the registered users samples, utterances are taken from a group of non-users. These utterances are used to form a composite that represents an impostor code having a plurality of impostor utterances.

In one embodiment, the code book generator 18 determines whether the speaker (users and non-users) is male or female. The male training utterances (male group) are aggregated to determining a male variance vector. The female training utterances (female group) are aggregated to determine a female variance vector. These gender specific variance vectors will be used when calculating a weighted Euclidean distance (measure of closeness) in the verification phase.

In the verification phase the switch 16 connects the feature extractor 14 to the comparator 22. The comparator 22 performs a mathematical analysis of the closeness between a test utterance from a speaker with a training utterance stored in the code book 20 and between the test utterance and an impostor utterance. In one embodiment, a test utterance such as a spoken "one" is compared with the "one" training utterance and the "one" impostor utterance in the code book 20. The comparator 22 determines a measure of closeness between the "one" training utterance, the "one" test utterance and the "one" impostor utterance. When the test utterance is closer to the training utterance than the impostor utterance, the speaker is verified as the true speaker. Otherwise the speaker is determined to be an impostor. In one embodiment, the measure of closeness is a modified weighted Euclidean distance. The modification in one embodiment involves using a generalized variance vector instead of an individual variance vector for each of the registered users. In another embodiment, a male variance vector is used for male speakers and a female variance vector is used for a female speaker.

A decision weighting and combining system 24 uses the measure of closeness to determine if the test utterance is closest to the training utterance or the impostor utterance. When the test utterance is closer to the training utterance than impostor utterance, a verified decision is made. When the test utterance is not closer to the training utterance than the impostor utterance, an un-verified decision is made. These are preliminary decisions. Usually, the speaker is required to speak several utterances (e.g., "one", "three", "five", "twenty one"). A decision is made

for each of these test utterances. Each of the plurality of decisions is weighted and combined to form the verification decision.

The decisions are weighted because not all utterances provide equal reliability. For instance, "one" could provide a much more reliable decision than "eight". As a result, a more accurate verification decision can be formed by first weighting the decisions based on the underlying utterance. Two weighting methods can be used. One weighting method uses a historical approach. Sample utterances are compared to the training utterances to determine a probability of false alarm P_{FA} (speaker is not impostor but the decision is impostor) and a probability of miss P_M (speaker is impostor but the decision is true speaker). The P_{FA} and P_M are probability of errors. These probability of errors are used to weight each decision. In one embodiment the weighting factors (weight) are described by the equation below:

$$a_i = \log \frac{1 - P_{Mi}}{P_{FAi}} \quad \text{Decision is Verified (True Speaker)}$$

$$a_i = \log \frac{P_{Mi}}{1 - P_{FAi}} \quad \text{Decision is Not Verified (Impostor)}$$

When the sum of the weighted decisions is greater than zero, then the verification decision is a true speaker. Otherwise the verification decision is an impostor.

The other method of weighting the decisions is based on an immediate evaluation of the quality of the decision. In one embodiment, this is calculated by using a Chi-Squared detector. The decisions are then weighted on the confidence determined by the Chi-Squared detector. In another embodiment, a large sample approximation is used. Thus if the test statistics are t, find b such that $c^2(b) = t$. Then a decision is an impostor if it exceeds the 1-a quantile of the c^2 distribution.

One weighting scheme is shown below:

1.5, if $b > c_{accept}$

1.0, if $1\text{-}a \leq b \leq c_{accept}$

-1.0, if $c_{reject} \leq b \leq 1\text{-}a$

-1.25, if $b < c_{reject}$

When the sum of the weighted decisions is greater than zero, then the verification decision is a true speaker. When the sum of the weighted decision is less than or equal to zero, the decision is an impostor.

In another embodiment, the feature extractor 14 segments the speech signal into voiced sounds and unvoiced sounds. Voiced sounds generally include vowels, while most other sounds are unvoiced. The unvoiced sounds are discarded before the cepstrum coefficients are calculated in both the training phase and the verification phase.

These techniques of weighting the decisions, using gender dependent cepstrums and only using voiced sounds can be combined or used separately in a speaker verification system.

FIG. 2 is a flow chart of an embodiment of the steps used to form a speaker verification decision. The process starts, at step 40, by generating a code book at step 42 The code book has a plurality of training utterances for each the plurality of speakers (registered users, plurality of people) and a plurality of impostor utterances. The training utterances in one embodiment are the cepstrum coefficients for a particular user speaking a particular utterance (e.g., "one). The training utterances are generated by a user speaking the utterances. The cepstrum coefficients of each of the utterances are determined to form the training utterances. In one embodiment a speaker is asked to repeat the utterance and a generalization of the two utterances is saved as the training utterance. In another embodiment both utterances are saved as training utterances.

In one embodiment, a data base of male speakers is used to determine a male variance vector and a data base of female speakers is used to determine a female variance vector. In another embodiment, the data bases of male and female speakers are used to form a male impostor code book and a female impostor code book. The gender specific variance vectors are stored in the code book. At step 44, a plurality of test utterances (input set of utterances) from a speaker are received. In one embodiment the cepstrum coefficients of the test utterances are calculated. Each of the plurality of test utterances are compared to the plurality of training utterances for the speaker at step

46. Based on the comparison, a plurality of decision are formed, one for each of the plurality of training utterances. In one embodiment, the comparison is determined by a Euclidean weighted distance between the test utterance and the training utterance and between the test utterance and an impostor utterance. In another embodiment, the Euclidean weighted distance is calculated with the male variance vector if the speaker is a male or the female variance vector if the speaker is a female. Each of the plurality of decisions are weighted to form a plurality of weighted decisions at step 48. The weighting can be based on historical error rates for the utterance or based on a confidence level (confidence measure) of the decision for the utterance. The plurality of weighted decisions are combined at step 50. In one embodiment the step of combining involves summing the weighted decisions. A verification decision is then made based on the combined weighted decisions at step 52, ending the process at step 54. In one embodiment if the sum is greater than zero, the verification decision is the speaker is a true speaker, otherwise the speaker is an impostor.

FIG. 3 is a flow chart of an embodiment of the steps used to form a code book for a speaker verification decision. The process starts, at step 70, by receiving an input utterance at step 72. In one embodiment, the input utterances are then segmented into a voiced sounds and an unvoiced sounds at step 74. The cepstrum coefficients are then calculated using the voiced sounds at step 76. The coefficients are stored as a training utterance for the speaker at step 78. The process then returns to step 72 for the next input utterance, until all the training utterances have been stored in the code book.

FIG. 4 is a flow chart of an embodiment of the steps used to form a speaker verification decision. The process starts, at step 100, by receiving input utterances at step 102. Next, it is determined if the speaker is male or female at step 104. In a speaker verification application, the speaker purports to be someone in particular. If the person purports to be someone that is a male, then the speaker is assumed to be male even if the speaker is a female. The input utterances are then segmented into a voiced sounds and an unvoiced sounds at step 106. Features (e.g., cepstrum coefficients) are extracted from the voiced sounds to form the test utterances, at step 108. At step 110, the weighted Euclidean distance (WED) is calculated using either a generalized male variance vector if the purported speaker is a male. When the purported speaker is a female, the female variance vector is used. The WED is calculated between the test utterance and the training utterance for the speaker and the test utterance and the male (or female if appropriate) impostor utterance. A decision is formed for each test utterance based on the WED at step 112. The decisions are then weighted based on a confidence level (measure of confidence) determined using a Chi-squared detector at step 114. The weighted decisions are summed at step 116. A verification decision is made based on the sum of the weighted decisions at step 118.

Using the speaker verification decisions discussed above results in an improved speaker verification system, that is more reliable than present techniques.

A dial-up service that uses a speaker verification method as described above is shown in FIG. 5. The dial-up service is shown as a

banking service. A user dials a service number on their telephone 150. The public switched telephone network (PSTN) 152 then connects the user's phone 150 with a dial-up service computer 154 at a bank 156. The dial-up service need not be located within a bank. The service will be explained in conjunction with the flow chart shown in FIG. 6. The process starts, at step 170, by dialing a service number (communication service address, number) at step 172. The user (requester) is then prompted by the computer 154 to speak a plurality of digits (access code, plurality of numbers, access number) to form a first utterance at step 174. The digits are recognized using speaker independent voice recognition at step 176. When the user has used the dial-up service previously, verifying the user based on the first utterance at step 178. When the user is verified as a true speaker at step 178, allowing access to the dial-up service at step 180. When the user cannot be verified, requesting the user input a personal identification number (PIN) at step 182. The PIN can be entered by the user either by speaking the PIN or by enter the PIN on a keypad. At step 184 it is determined if the PIN is valid. When the PIN is not valid, the user is denied access at step 186. When the PIN is valid the user is allowed access to the service at step 180. Using the above method the dial-up service uses a speaker verification system as a PIN option, but does not deny access to the user if it cannot verify the user.

FIG. 7 is a flow chart of another embodiment of the steps used in a dial-up service. The process starts, step 200, by the user speaking an access code to form a plurality of utterances at step 202. At step 204 it is determined if the user has previously accessed the service. When the

user has previously used the service, the speaker verification system attempts to verify the user (identity) at step 206. When the speaker verification system can verify the user, the user is allowed access to the system at step 208. When the system cannot verify the user, a PIN is requested at step 210. Note the user can either speak the PIN or enter the PIN on a keypad. At step 212 it is determined if the PIN is valid. When the PIN is not valid the user is denied access at step 214. When the PIN is valid, the user is allowed access at step 208.

When the user has not previously accessed the communication service at step 204, the user is requested to enter a PIN at step 216. At step 218 it is determined if the PIN is valid at step 218. When the PIN is not valid, denying access to the service at step 220. When the PIN is valid the user is asked to speak the access code a second time to form a second utterance (plurality of second utterances) at step 222. The similarity between the first utterance (step 202) and the second utterance is compared to a threshold at step 224. In one embodiment the similarity is calculated using a weighted Euclidean distance. When the similarity is less than or equal to the threshold, the user is asked to speak the access code again at step 222. In this case the second and third utterances would be compared for the required similarity. In practice, the user would not be required to repeat the access code at step 222 more than once or twice and the system would then allow the user access. When the similarity is greater than the threshold, storing a combination of the two utterances as at step 226. In another embodiment both utterances are stored as reference utterances. Next access to the service is allowed at step 208. The reference utterance

(plurality of reference utterances, reference voiced sounds) is used to verify the user the next time they access the service. Note that the speaker verification part of the access to the dial-up service in one embodiment uses all the techniques discussed for a verification process. In another embodiment the verification process only uses one of the speaker verification techniques. Finally, in another embodiment the access number has a predetermined digit that is selected from a first set of digits (predefined set of digits) if the user is a male. When the user is a female, the predetermined digit is selected from a second set of digits. This allows the system to determine if the user is suppose to be a male or a female. Based on this information, the male variance vector or female variance vector is used in the speaker verification process.

Thus there has been described an improved speaker verification method and a service that takes advantage of the speaker verification method. While the invention has been described in conjunction with specific embodiments thereof, it is evident that many alterations, modifications, and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace all such alterations, modifications, and variations in the appended claims.

Claims

What is claimed is:

1. A speaker verification method comprising the steps of:

(a) generating a code book covering a plurality of speakers having a plurality of training utterances for each of the plurality of speakers;

(b) receiving a plurality of test utterances from a speaker;

(c) comparing each of the plurality of test utterances to each of the plurality of training utterances for the speaker to form a plurality of decisions, one decision of the plurality of decisions for each of the plurality of test utterances;

(d) weighting each of the plurality of decisions to form a plurality of weighted decisions; and

(e) combining the plurality of weighted decisions to form a verification decision.

2. The method of claim 1, wherein step (c) further includes the step of:

(c1) comparing each of the plurality of test utterances to each of a plurality of impostor utterances.

3. The method of claim 1, wherein step (d) further includes the steps of:

(d1) determining a measure of confidence for each of the plurality of decisions;

(d2) assigning a weight for each of the plurality of decisions based on the measure of confidence.

4. The method of claim 1, wherein step (a) further includes the steps of:

(a1) separating the plurality of speakers into a male group and a female group;

(a2) determining a male variance vector from the male group;

(a3) determining a female variance vector from the female group.

5. The method of claim 1, wherein step (c) further including the steps of:

(c1) determining if the speaker of the plurality of test utterances is a male or a female;

(c2) when the speaker is male, using the male variance vector to determine a weighted Euclidean distance between each of the plurality of test utterances and each of the plurality of training utterances for the speaker;

(c3) forming a decision for each of the plurality of test utterances based on the weighted Euclidean distance.

6. The method of claim 4, wherein step (c) further including the steps of:

(c1) determining if the speaker of the test utterances is a male or a female;

(c2) when the speaker is female, using the female variance vector to determine a weighted Euclidean distance between each of the plurality of test utterances and each of the plurality of training utterances for the speaker;

(c3) forming a decision for each of the plurality of test utterances based on the weighted Euclidean distance.

7. The method of claim 1, wherein step (a) further includes the steps of:

(a1) receiving a sample utterance;

(a2) segmenting the sample utterance into a voiced sounds and an unvoiced sounds;

(a3) storing the voiced sounds as one of the plurality of training utterances.

8. The method of claim 7, wherein step (b) further includes the steps of:

(b1) receiving an input set of utterances;

(b2) segmenting the input set of utterances into the voiced sounds and the unvoiced sounds;

(b3) storing the voiced sounds to form the plurality of test utterances.

9. A method of speaker verification, comprising the steps:

(a) generating a code book containing a plurality of training utterances for a plurality of people and a male variance vector, a female variance vector and a plurality of impostor utterances;

(b) receiving a plurality of test utterances from a speaker;

(c) determining if the speaker is a male;

(d) when the speaker is male, using the male variance vector to determine a weighted Euclidean distance between each of the plurality of test utterances and the plurality of training utterances;

(e) determining a weighted Euclidean distance between each of the plurality of test utterances and the plurality of impostor utterances;

(f) forming a decision for each of the plurality of test utterances to form a plurality of decisions; and

(g) combining the plurality of decisions to form the verification decision.

10. The method of claim 9, wherein step (f) further includes the step of:

(f1) comparing the weighted Euclidean distance for each the plurality of training utterances to the weighted Euclidean distance for each of the plurality of impostor utterances to form a comparison;

(f2) forming a decision based on the comparison.

11. The method of claim 9, wherein step (g) further includes the steps of:

(g1) weighting each of the plurality of decisions based on a confidence measure to form a plurality of weighted decisions;

(g2) summing the plurality of weighted decisions to form a verification decision.

12. The method of claim 9, wherein step (a) further includes the steps of:

(a1) receiving a sample utterance;

(a2) segmenting the sample utterance into a voiced sounds and an unvoiced sounds;

(a3) storing the voiced sounds as one of the plurality of training utterances.

13. The method of claim 12, wherein step (b) further includes the steps of:

(b1) receiving an input set of utterances;

(b2) segmenting the input set of utterances into the voiced sounds and the unvoiced sounds;

(b3) storing the voiced sounds to form the plurality of test utterances.

14. A computer readable storage medium containing computer readable instructions that when executed by a computer performs the following steps:

(a) generates a code book covering a plurality of speakers having a plurality of training utterances for each of the plurality of speakers;

(b) receives a plurality of test utterances from a speaker;

(c) compares each of the plurality of test utterances to each of the plurality of training utterances in the code book to form a plurality of decisions, one decision of the plurality of decisions for each of the plurality of test utterances;

(d) weights each of the plurality of decisions to form a plurality of weighted decisions; and

(e) combines the plurality of weighted decisions to form a verification decision.

15. The method of claim 14, wherein step (c) further includes the step of:

(c1) comparing each of the plurality of test utterances to each of a plurality of impostor utterances.

16. The computer readable storage medium of claim 14, wherein step (d) further includes the steps of:

(d1) determines a measure of confidence for each of the plurality of decisions;

(d2) assigns a weight for each of the plurality of decisions based on the measure of confidence.

17. The computer readable storage medium of claim 14, wherein step (a) further includes the steps of:

(a1) separates the plurality of speakers into a male group and a female group;

(a2) determines a male variance vector from the male group;

(a3) determines a female variance vector from the female group.

18. The computer readable storage medium of claim 14, wherein step (c) further including the steps of:

(c1) determines if the speaker of the plurality of test utterances is a male or a female;

(c2) when the speaker is male, using the male variance vector to determine a weighted Euclidean distance between each of the plurality of test utterances and each of the plurality of training utterances for the speaker;

(c3) forms a decision for each of the plurality of test utterances based on the weighted Euclidean distance.

19. The computer readable storage medium of claim 17, wherein step (c) further including the steps of:

(c1) determines if the speaker of the plurality of test utterances is a male or a female;

(c2) when the speaker is female, using the female variance vector to determine a weighted Euclidean distance between each of the plurality of test utterances and each of the plurality of training utterances for the speaker;

(c3) forms a decision for each of the plurality of test utterances based on the weighted Euclidean distance.

20. The computer readable storage medium of claim 14, wherein step (a) further includes the steps of:

(a1) receives a sample utterance;

(a2) segments the sample utterance into a voiced sounds and an unvoiced sounds;

(a3) stores the voiced sounds as one of the plurality of training utterances.

21. The computer readable storage medium of claim 20, wherein step (b) further includes the steps of:

(b1) receives an input set of utterances;

(b2) segments the input set of utterances into the voiced sounds and the unvoiced sounds;

(b3) stores the voiced sounds to form the plurality of test utterances.

SPEAKER VERIFICATION METHOD

Abstract of the Disclosure

A speaker verification method consist of the following steps: (1) generating a code book (42) covering a number of speakers having a number of training utterances for each of the speakers; (2) receiving a number of test utterances (44) from a speaker; (3) comparing (46) each of the test utterances to each of the training utterances for the speaker to form a number of decisions, one decision for each of the number of test utterances; (4) weighting each of the decisions (48) to form a number of weighted decisions; and (5) combining (50) the plurality of weighted decisions to form a verification decision (52).

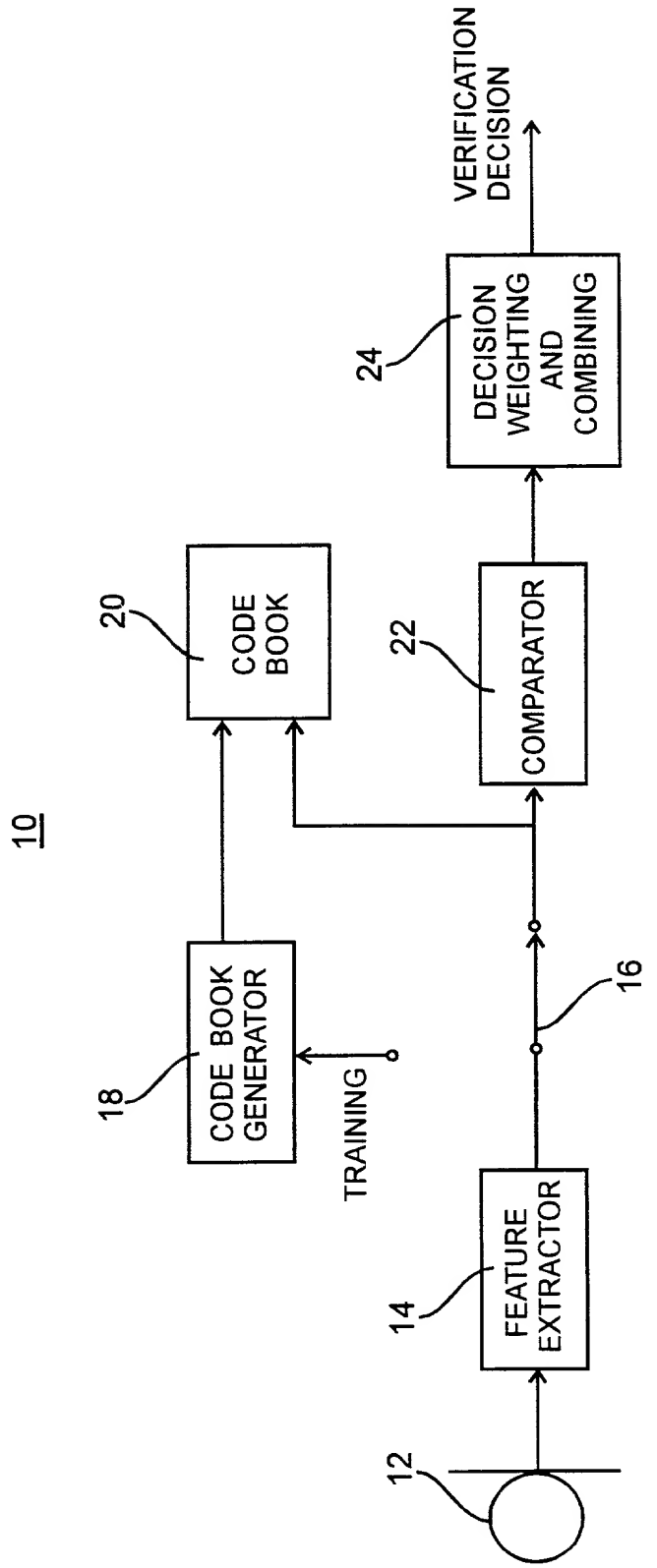
10
12
14
FEATURE EXTRACTOR
16
18
CODE BOOK GENERATOR
TRAINING
20
CODE BOOK
22
COMPARATOR
24
DECISION WEIGHTING AND COMBINING
VERIFICATION DECISION

Fig. 1

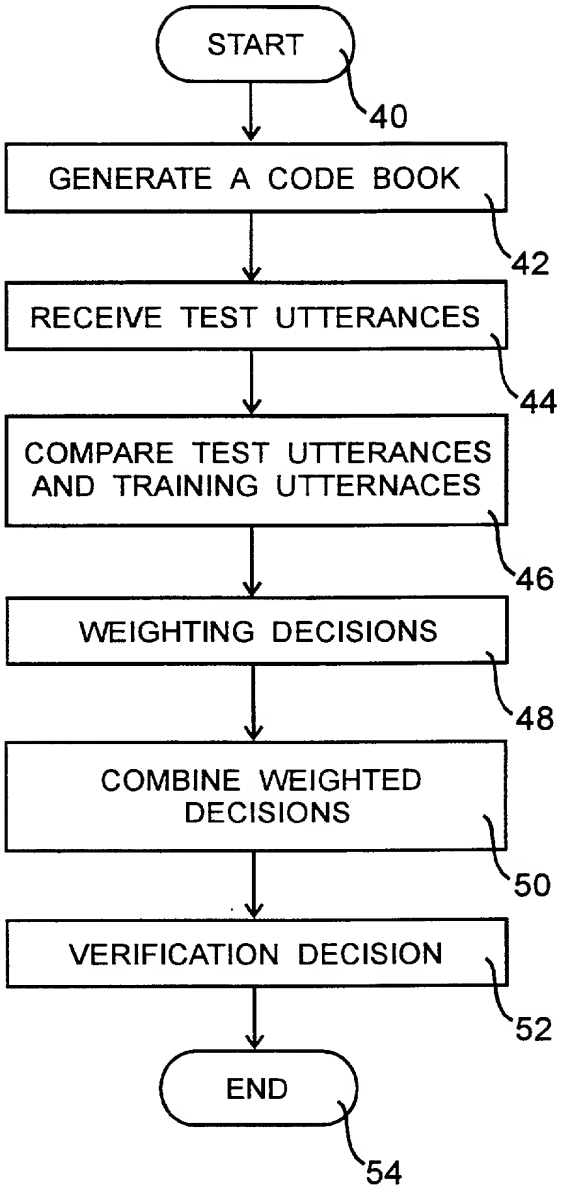
START
40
GENERATE A CODE BOOK
42
RECEIVE TEST UTTERANCES
44
COMPARE TEST UTTERANCES AND TRAINING UTTERNACES
46
WEIGHTING DECISIONS
48
COMBINE WEIGHTED DECISIONS
50
VERIFICATION DECISION
52
END
54

Fig. 2

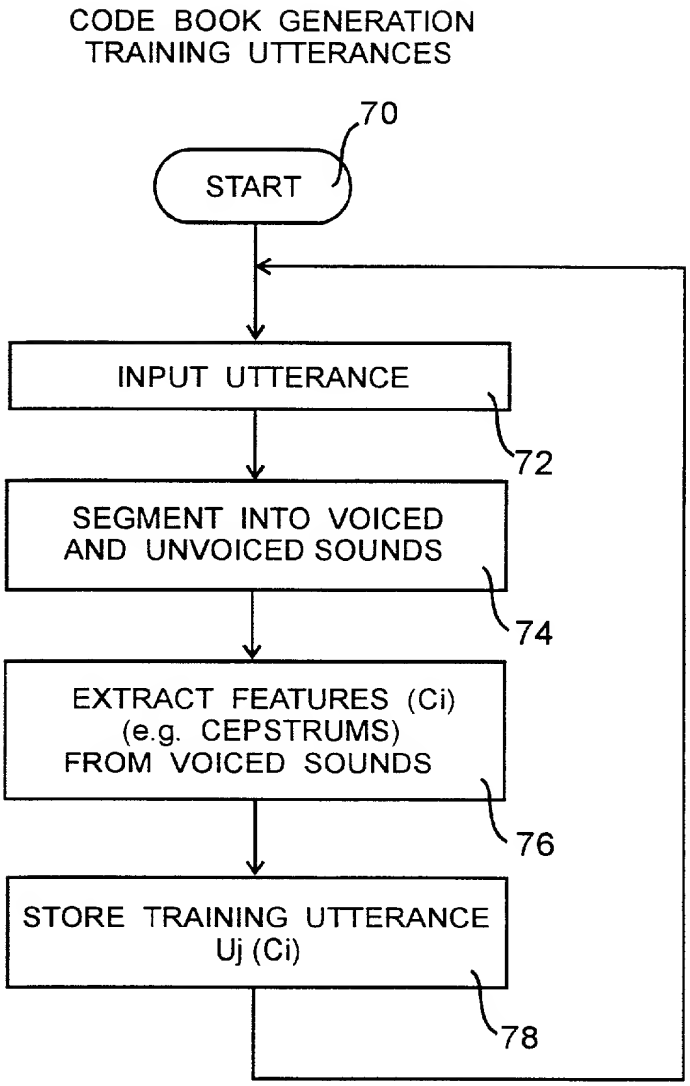
CODE BOOK GENERATION
TRAINING UTTERANCES
70
START
INPUT UTTERANCE
72
SEGMENT INTO VOICED
AND UNVOICED SOUNDS
74
EXTRACT FEATURES (Ci)
(e.g. CEPSTRUMS)
FROM VOICED SOUNDS
76
STORE TRAINING UTTERANCE
Uj (Ci)
78

Fig. 3

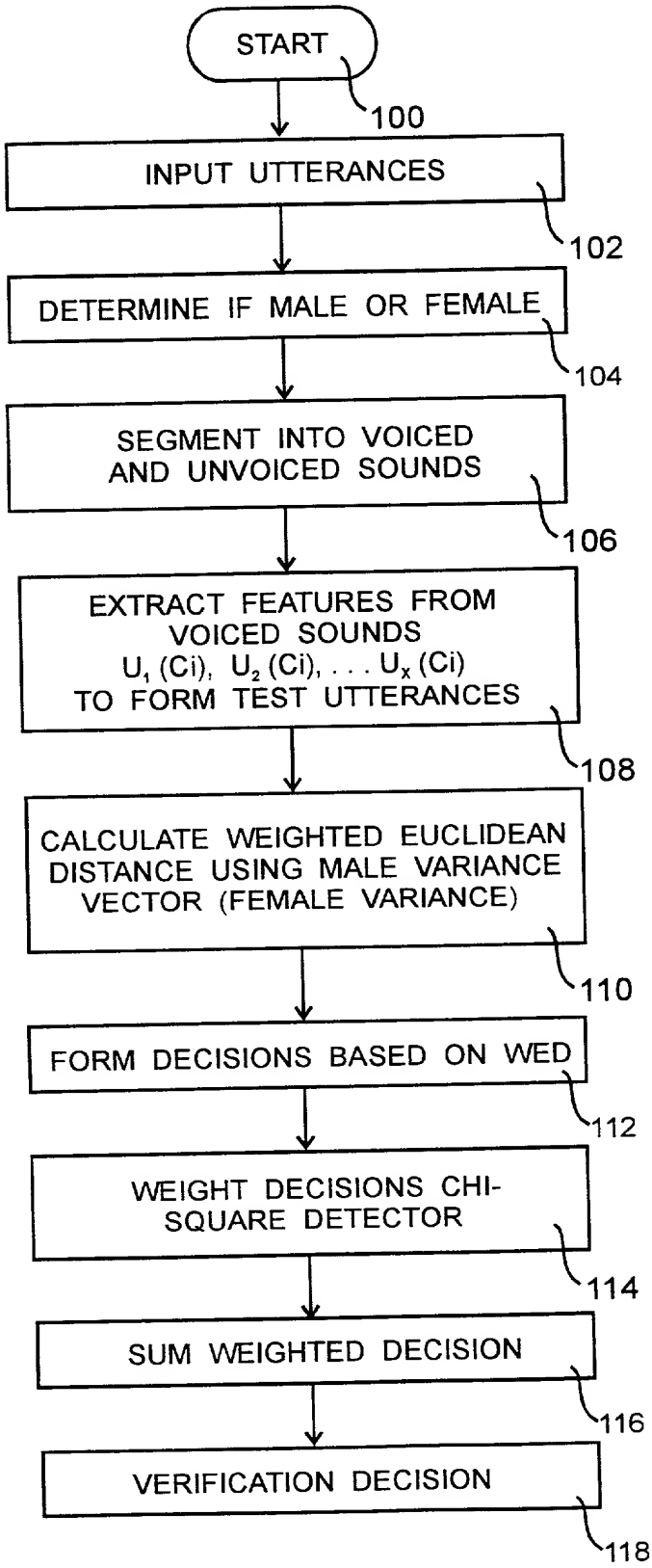
VERIFICATION DECISION
START
100
INPUT UTTERANCES
102
DETERMINE IF MALE OR FEMALE
104
SEGMENT INTO VOICED AND UNVOICED SOUNDS
106
EXTRACT FEATURES FROM VOICED SOUNDS
U_1 (Ci), U_2 (Ci), . . . U_x (Ci)
TO FORM TEST UTTERANCES
108
CALCULATE WEIGHTED EUCLIDEAN DISTANCE USING MALE VARIANCE VECTOR (FEMALE VARIANCE)
110
FORM DECISIONS BASED ON WED
112
WEIGHT DECISIONS CHI-SQUARE DETECTOR
114
SUM WEIGHTED DECISION
116
VERIFICATION DECISION
118

Fig. 4

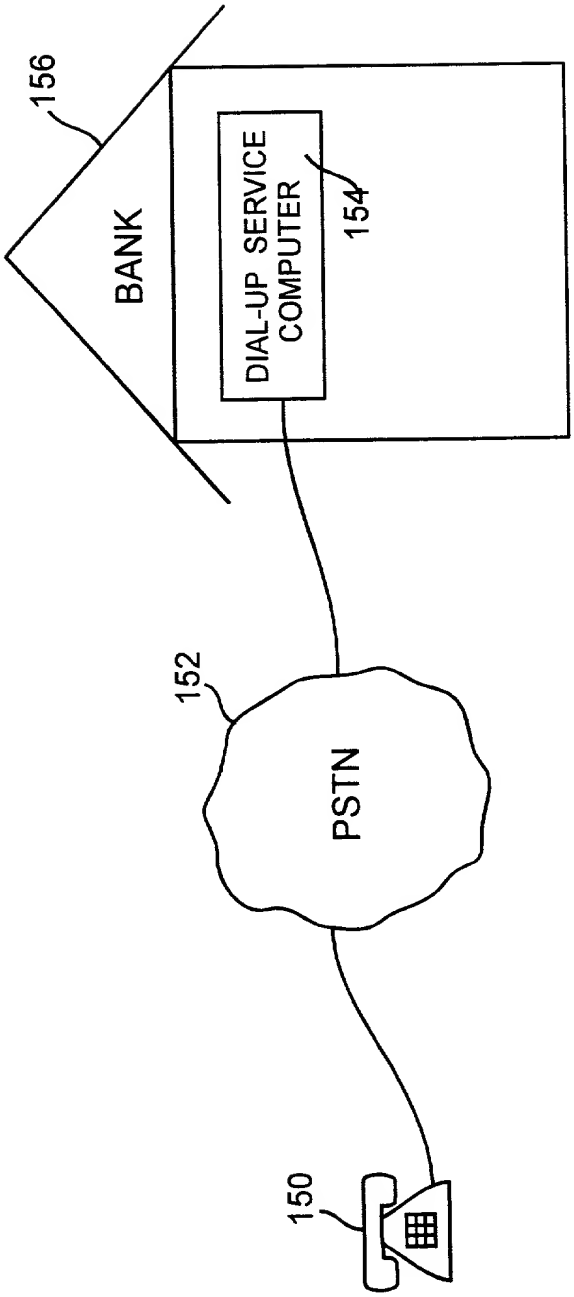

Fig. 5

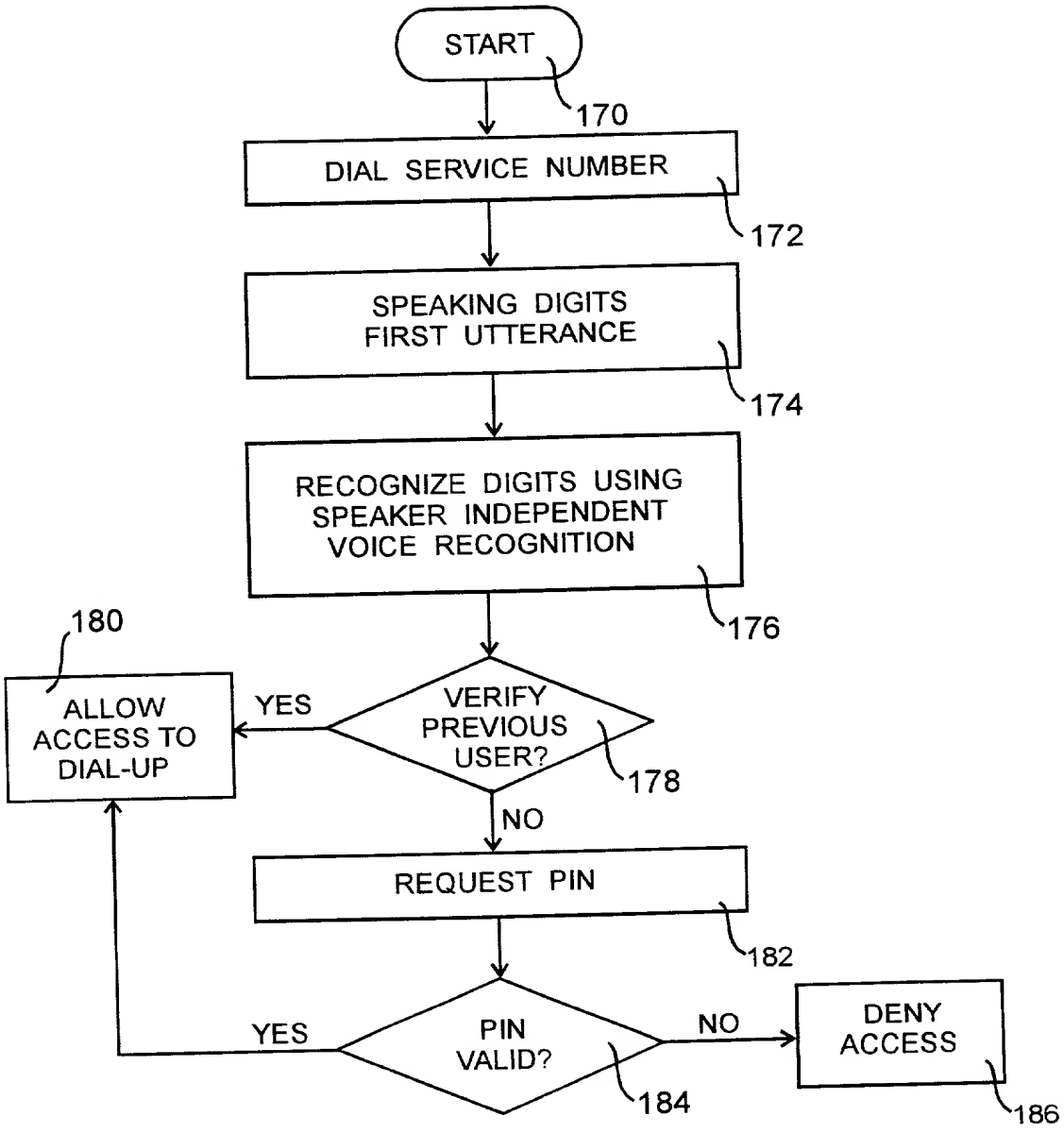
START
170
DIAL SERVICE NUMBER
172
SPEAKING DIGITS FIRST UTTERANCE
174
RECOGNIZE DIGITS USING SPEAKER INDEPENDENT VOICE RECOGNITION
176
180
ALLOW ACCESS TO DIAL-UP
YES
VERIFY PREVIOUS USER?
178
NO
REQUEST PIN
182
YES
PIN VALID?
NO
DENY ACCESS
184
186

Fig. 6

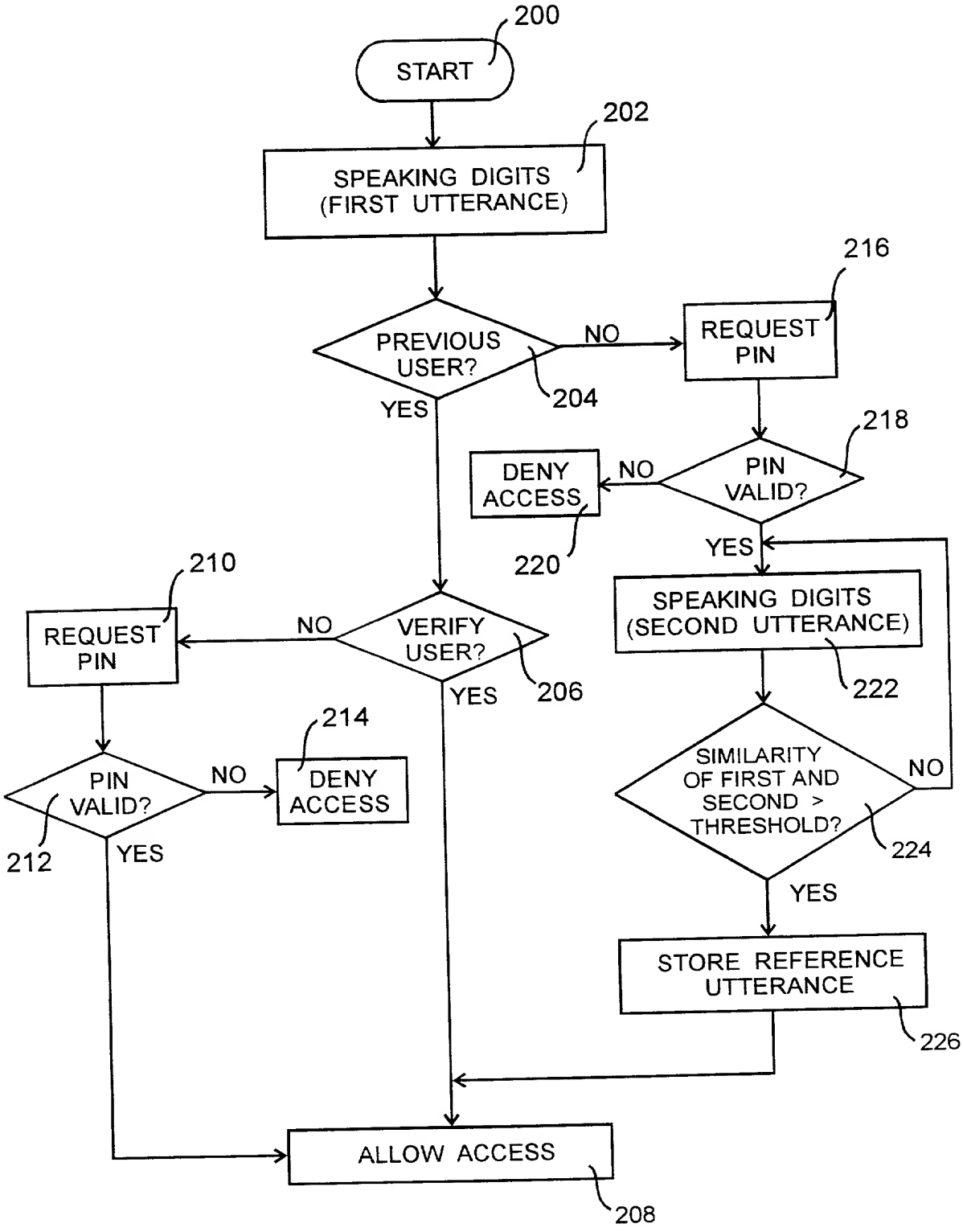
200
START
202
SPEAKING DIGITS (FIRST UTTERANCE)
PREVIOUS USER?
NO
204
YES
216
REQUEST PIN
218
PIN VALID?
NO
DENY ACCESS
220
YES
SPEAKING DIGITS (SECOND UTTERANCE)
222
SIMILARITY OF FIRST AND SECOND > THRESHOLD?
NO
224
YES
STORE REFERENCE UTTERANCE
226
210
REQUEST PIN
NO
VERIFY USER?
206
YES
214
PIN VALID?
NO
DENY ACCESS
212
YES
ALLOW ACCESS
208

Fig. 7

PATENT APPLICATION DECLARATION COMBINED
WITH POWER OF ATTORNEY

__X__ REGULAR (UTILITY) OR _____ DESIGN APPLICATION
(check one)

As a below-named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: "Speaker Verification Method" the specification of which:

_____ is attached hereto.

__X__ was filed on May 27, 1997 as U.S. Application Serial No. 08/863,444
and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulation, Section 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s):

__X__ no such applications filed

_____ such applications identified as follows:

			Priority Claimed	
(Serial No.)	(Country)	(Day/Month/Year Filed	Yes	No
(Serial No.)	(Country)	(Day/Month/Year Filed	Yes	No
(Serial No.)	(Country)	(Day/Month/Year Filed	Yes	No

I hereby claim the priority benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, Section 1.56(a) which is material to the examination of this application and which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Prior U.S. Application(s):

(Check one) _X_ no such applications filed

____ such applications identified as follows:

(Application Serial No.)	(Filing Date)	(Status) (Patented, Pending, Abandoned)
(Application Serial No.)	(Filing Date)	(Status) (Patented, Pending, Abandoned)
(Application Serial No.)	(Filing Date)	(Status) (Patented, Pending, Abandoned)

I hereby declare that: as to any claimed subject matter of this application which is common to my earlier United States or foreign application(s), if any, which I have identified above and claimed the benefit of priority thereof, I do not believe that the same was ever known or used in the United States before my invention thereof or patented or described in any printed publication in any country before my invention thereof or more than one year prior to the first of said earlier application(s), or in public use or on sale in the United States more than one year prior to the first of said earlier application(s), and that the common subject matter has not been patented or made the subject of an inventor's certificate before the date of the first of said earlier U.S. application(s) in any country foreign to the United States on an application, filed by me or my legal representatives or assigns more than twelve months (six months if the present application is a Design patent application) prior to the first of said earlier U.S. application(s), if any; an that, as to any claimed subject matter of this application which is not common to said earlier application(s), if any, I do not know and do not believe that the same was ever known or used in the United States before my invention thereof or patented or described in any printed publication in any country before my invention thereof or more than one year prior to the date of this application, or in public use or on sale in the United States more than one year prior to the date of this application, and that said subject matter has not been patented or made the subject of an inventor's certificate in any country foreign to the United States on an application filed by me or my legal representatives or assigns more than twelve months (six months if the present application is a design patent application) prior to the date of this application.

I HEREBY APPOINT THE FOLLOWING AS MY ATTORNEY(S) OR AGENT(S) WITH FULL POWER OF SUBSTITUTION TO PROSECUTE THIS APPLICATION AND TRANSACT ALL BUSINESS IN THE PATENT AND TRADEMARK OFFICE CONNECTED THEREWITH:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statement and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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